# THE REPRESENTATION OF HUMAN BEHAVIOR IN COMBAT SIMULATIONS:

## Human Decisionmaking in the Naval Simulation System (NSS)

Prepared

for

DMSO Human Behavior Representation Workshop

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# OUTLINE

- NSS BACKGROUND
  - Design Overview
  - Targeted Users and Uses
  - Object Taxonomy
  - Architecture
- HBR TERMS OF REFERENCE RESPONSES
  - Representation of Mission and Tasking
  - Representation of Unit State
  - Representation of Physical Environment
  - Dynamic Behavioral Responses
  - Architectural Aspects of Simulations Representing Human Behavior
  - Other Issues
- SUMMARY

# NSS BACKGROUND - 1

- **Purpose:** Support Naval studies and analyses, decision support applications, and training. Constructive and virtual modes of operation.

- **Design Features:** Object-oriented;

  Monte Carlo;

  Multi-resolution;

  Entity level (with some aggregation);

  Motion in 3D on a spherical earth;

  Explicit treatment of command structure, operational plans and tactics, data fusion (perception), communications, sensors, weapons, and countermeasures.

- **Architectural Compliance:** HLA (FY-96)

  JMCIS (FY-97)

# NSS BACKGROUND - 2

- Targeted Users: OPNAV N81, Joint Staff J-8/WAD, CINCPACFLT

- Targeted Uses: Analysis/Assessment/Acquisition
  - Investment Balance Review (IBR) assessments
  - Joint Mission Area (JMA) assessments
  - Cost and Operational Effectiveness Analyses (COEAs)

  Fleet Operations Planning/Decision Support (via JMCIS)
  - Command assessment of operational plans
  - Rapid alternate course of action (COA) evaluation
  - Fleet command requirements assessment

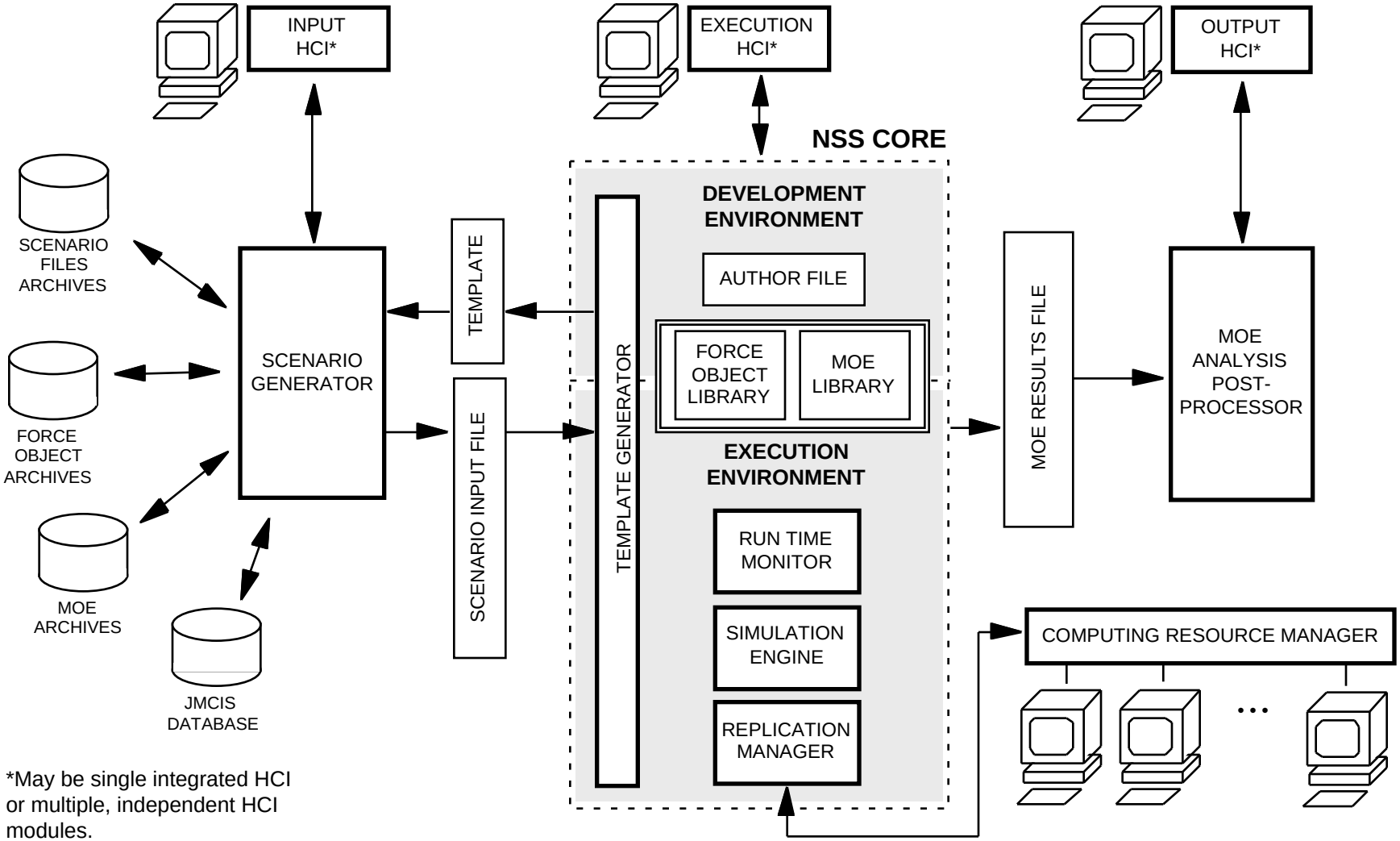
  Man-in-the-Loop Simulation
  - Analyst interactive mode of operation

# NSS BACKGROUND - 3

## NSS Object Taxonomy

# NSS BACKGROUND - 4

## NSS Architecture




*May be single integrated HCI or multiple, independent HCI modules.

# OUTLINE

- NSS BACKGROUND
  - Design Overview
  - Targeted Users and Uses
  - Object Taxonomy
  - Architecture

- HBR TERMS OF REFERENCE RESPONSES
  - Key Drivers
    - Representation of Mission and Tasking
    - Representation of Unit State
    - Representation of Physical Environment
    - Dynamic Behavioral Response
  - Architectural Aspects of Simulations Representing Human Behavior
  - Other Issues

- SUMMARY

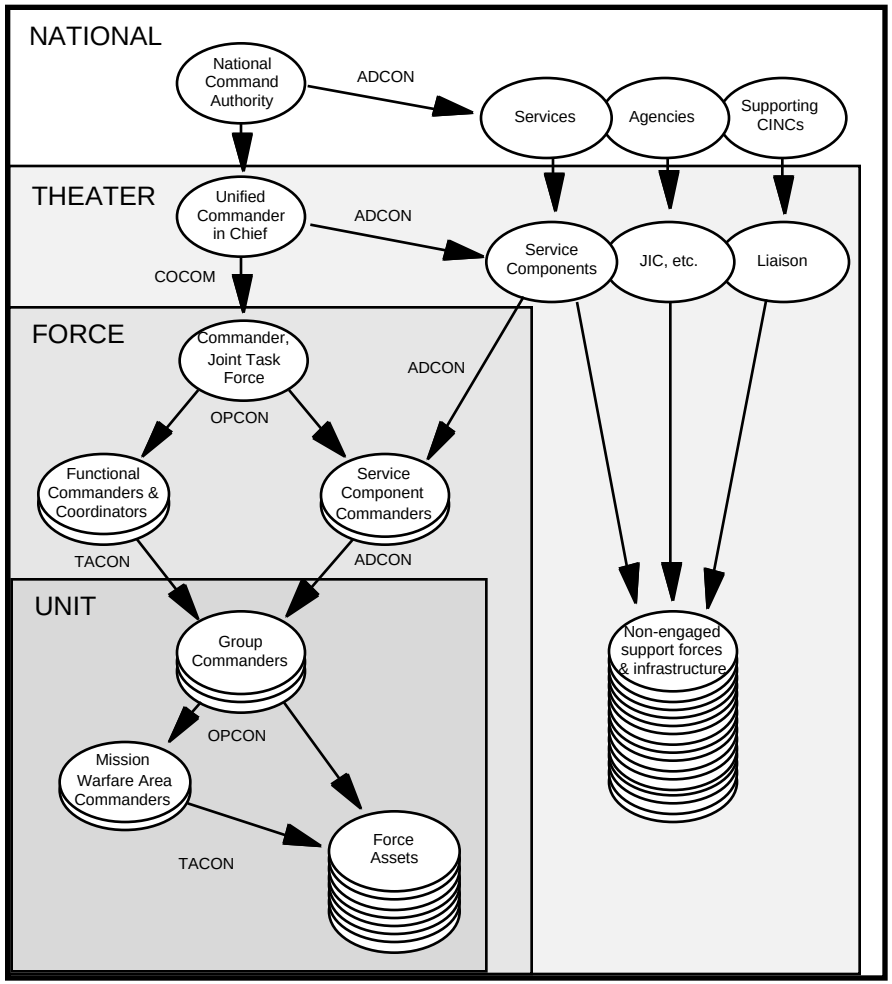
# HBR TERMS OF REFERENCE QUESTIONS

KEY DRIVERS OF HUMAN BEHAVIOR REPRESENTATION

- **Representation of Mission and Tasking.** What military operations does your model represent? How detailed is the task structure of your model? What echelon of command does your model specify on tasks?
- **Representation of Unit State.** How does your simulation represent a commander's situational awareness? Is it represented as "ground truth" or is the knowledge a result of "situation reports" from friendly forces and intelligence resources? How does your model represent unit readiness and training? How is communication represented? How does the unit know about the enemy? How are national, cultural, and leadership differences represented?
- **Representation of Physical Environment.** What militarily significant terrain features does your model handle? Does your model capture dynamic terrain features? Is the model slower or faster than real time? Does it support distributed processes? How is weather or other significant environmental phenomenology represented?
- **Dynamic Behavioral Responses.** Can commanders in your model modify planned actions? How is C2 represented in the model? Does commander behavior figure? Does your model use human-in-the-loop (HITL) for decisionmaking at some echelon level? How do you simulate unit behavior?

# HBR TERMS OF REFERENCE RESPONSES

**I(1). Representation of Mission and Tasking:** What echelon of command does your model specify on tasks?

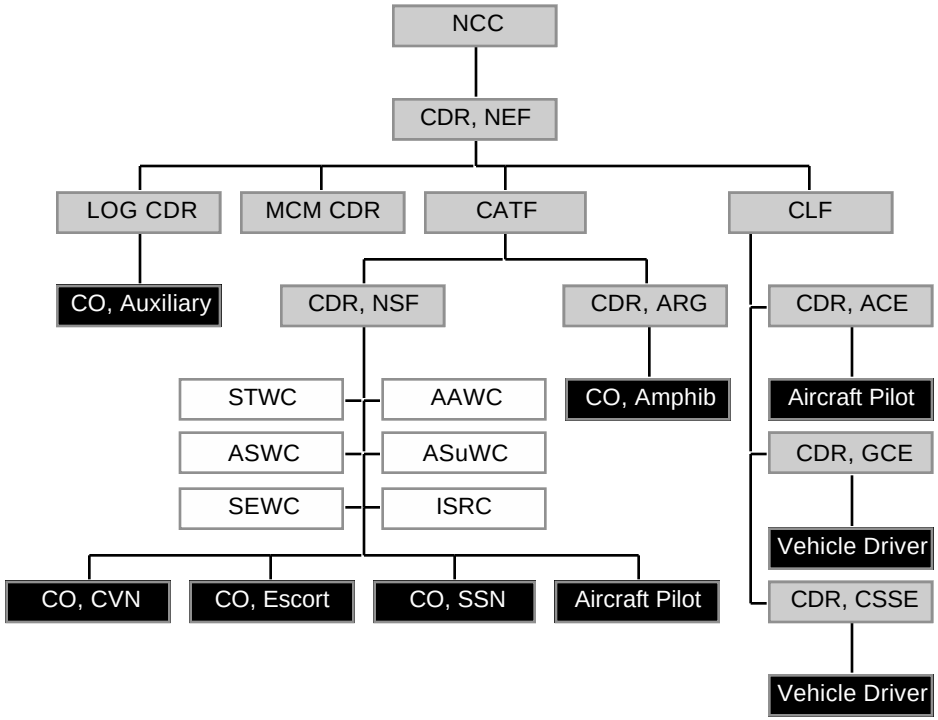



**NSS Capability:**

- National/Theater Levels:
  - User specified order of battle (OOB).
  - User specified command structures.
  - User specified time phased arrival of forces.
- Force/Unit Levels:
  - Fully dynamic and responsive treatment of commanders and the command decision process.
- Complicated command structures may be defined using three generic commander types:
  - Group Commander,
  - Warfare Mission Area (WMA) Commander,
  - Asset Commander.

# HBR TERMS OF REFERENCE RESPONSES

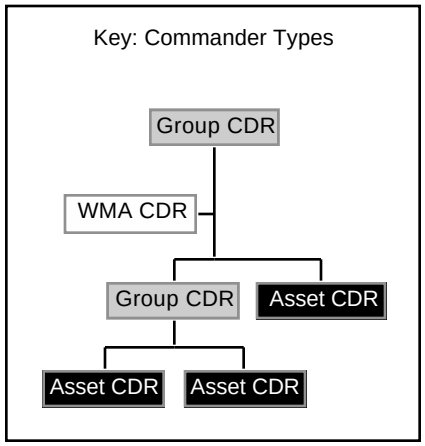
**I(1). Representation of Mission and Tasking:** How detailed is the task structure of your model?




**NSS Command Structures:**

NSS represents command decision-making within the context of user-defined hierarchical command structures composed of three generic commander types: **Group**, **WMA**, and **Asset**.

Functionality associated with these commander types is discussed below.



# HBR TERMS OF REFERENCE RESPONSES

**I(2). Representation of Unit State:** How does your simulation represent a commander's situational awareness?

Military operations are heavily **information driven**. NSS explicitly represents the systems and system architectures which are used to collect and disseminate this information. Representation of intelligence processes is the subject of ongoing NSS development.

### Surveillance Architecture

(1) ***Representation of Surveillance Plan***
- Allocate resources (static + responsive).
- Minimize susceptibility to counterdetection.

(2) ***Representation of System Capabilities***
- Detectability spectrum.
- Dependence on mode, threat, environment.
- Reporting content and uncertainties.
- Reporting frequency.
- Susceptibility to counterdetection.

(3) ***Representation of Threat Susceptibility***
- Susceptibility spectrum.
- Dependence on operating profile, environment.
- Tactics to avoid detection.
- Tactics once detected.

### Communications Architecture

(1) ***Representation of Communications Plan***
- Dissemination rules.
- Backup/redundant routing.
- Minimize susceptibility to interception.
- Minimize susceptibility to disruption.

(2) ***Representation of System Capabilities***
- Connectivity and throughput.
- Dependence on environment.
- Susceptibility to interception.
- Susceptibility to disruption.

(3) ***Representation of Networks***
- Participation requirements.
- Protocols.
- Operating modes.
- Responsive re-allocation rules.

# HBR TERMS OF REFERENCE RESPONSES

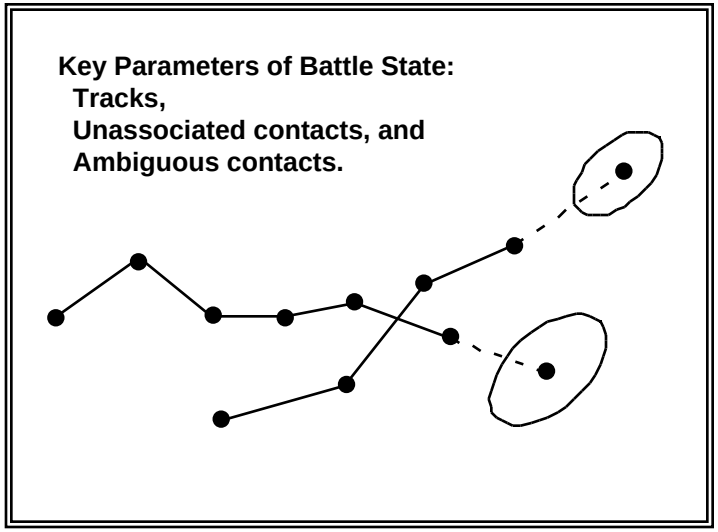
**I(2).Representation of Unit State:** Is a commander's situational awareness based on ground truth or is the knowledge a result of "situation reports" from friendly forces?

Military commanders act based upon a **perception** of the status of friendly, neutral, and hostile forces. This perception is formulated based upon the **information** available to the commander. NSS represents **each** commander's perception and simulates **all** commander decision-making based on this simulated perception.

**Commander's Simulated Tactical Picture**

**Surveillance Products**

Intelligence Products




**Domains:**
Air
Land
Ocean Surface
Undersea

**Levels of Resolution:**
Perfect
DR, perfect correlation
DR, imperfect correlation
Kalman Filter

**Required Technologies:** Data Association / Correlation
State Estimation
Attribute Classification

# HBR TERMS OF REFERENCE RESPONSES

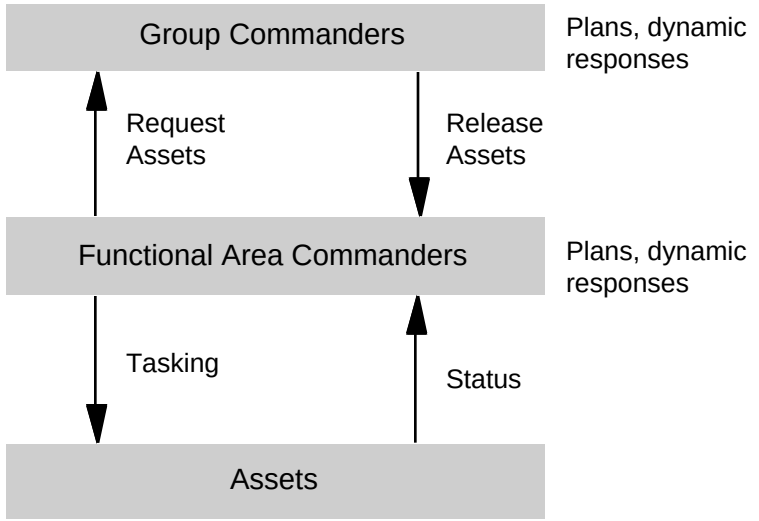
**I(3). Representation of the Physical Environment:** What militarily significant terrain features does your model handle? Does your model capture dynamic terrain features? How is weather or other significant environmental phenomenology represented?

- Discuss Environmental Provinces

# HBR TERMS OF REFERENCE RESPONSES

**I(4). Dynamic Behavioral Responses:** How is C2 represented in the model?

- Group Level Commanders
  - **Plans:** Group motion, priorities, reporting nets and circuits, readiness conditions, EMCON, weapon release status, UNREP, etc.
  - **Dynamic Responses:** Group level responses to I&W; e.g. change priorities, readiness conditions, EMCON, etc.
- Functional Area (WMA) Commanders
  - **Plans:** WMA specific plans; e.g. multi-phase strike plan, submarine search barrier operations plan, etc.
  - **Dynamic Responses:** Tactical responses to I&W plus responses to group commander directives.
- Asset Commanders
  - Plans and dynamic responses are provided by the commander(s) in tactical control (TACON) of the asset.



# HBR TERMS OF REFERENCE RESPONSES

**(4). Dynamic Behavioral Responses:** Does commander behavior figure?

Group Commander Priorities vs. Time

(Example) WMA Priority Table

| | Default Conditions (Scenario Hrs) | | | | Exceptions | | | |
|---|---|---|---|---|---|---|---|---|
| **WMA** | 0 to 48 | 49 to 50 | 51 to 60 | etc | AAW Attack I&W | ASW Attack I&W | Mine I&W | etc |
| AAW | 3 | 4 | 2 | . | 1 | (current +1) | (current +1) | . |
| AMW | 8 | 8 | 8 | . | (current +1) | (current +1) | (current +1) | . |
| ASuW | 2 | 3 | 6 | . | (current +1) | (current +1) | (current +1) | . |
| ASW | 1 | 2 | 7 | . | (current +1) | 1 | (current +1) | . |
| LW | 9 | 9 | 9 | . | (current +1) | (current +1) | (current +1) | . |
| MCM | 4 | 5 | 4 | . | (current +1) | (current +1) | 1 | . |
| MIW | 5 | 1 | 5 | . | (current +1) | (current +1) | (current +1) | . |
| STW | 7 | 7 | 3 | . | (current +1) | (current +1) | (current +1) | . |
| TMD | 6 | 6 | 1 | . | (current +1) | (current +1) | (current +1) | . |

**Group Commander Priorities:**

A key element of each group commanders plan is the WMA priority table. This is used to resolve conflicts arising due to over-allocated assets.

# HBR TERMS OF REFERENCE RESPONSES

**I(4). Dynamic Behavioral Responses:** Does commander behavior figure?

- The battle objectives of the enemy are known to simulated friendly commanders **only** through the outputs of simulated tactical pictures. Recall that simulated tactical picture outputs depend entirely on simulated sensor and situation reports.

- Enemy objectives or intentions are determined and acted upon through the use of dynamic response **decision tables**, e.g.
  - If enemy minelayers are observed within region R during time interval I, deploy mine countermeasures tactic T.
  - If n or more enemy fighter aircraft are observed inbound within range R of defended asset A, deploy CAP grid G with launch and recovery cycle C.

- More advanced treatments of intelligence processes (e.g. assessments of threat objectives/intent based upon more complicated considerations) are needed.

# HBR TERMS OF REFERENCE RESPONSES

**(4). Dynamic Behavioral Responses:** Can commanders in your model modify planned actions?

- All simulated assessments of threat, neutral, and friendly forces are based upon the outputs of simulated tactical pictures available to the commander in question.

- Future battle status is projected using queries to the tactical picture in question. Some examples:
  - List all threat subsurface tracks which project to be within region R at future time t + T.
  - List all threat air tracks which project to be within range R of defended site S any time during time interval [t , t + T].

- Planned as well as responsive actions can be predicated upon such queries.

# HBR TERMS OF REFERENCE RESPONSES

**(4). Dynamic Behavioral Responses:** How is C2 represented in the model?

- All decision actions are represented via explicit simulated message passing over simulated communications systems/nets in accordance with the relevant communications plan.

- Types of decision actions modeled include:
  - Group commander orders subordinate commanders/assets to change motion, readiness conditions, EMCON status, weapon release status, etc.
  - WMA commander requests assets (or specific asset capabilities) from group commander.
  - Group commander releases assets (or specific asset capabilities) to WMA commander.
  - WMA commander tasks subordinate assets to intercept, conduct search and surveillance, engage, jam, etc.
  - Asset reports (system) status to WMA commander.

- Assets can process multiple (non-conflicting) orders in parallel.

# HBR TERMS OF REFERENCE RESPONSES

**(4) Simulating Unit Behavior:** What basic approach did you take towards simulating unit behavior?

At the group commander level and below, decision making is fully dynamic/ reactive for an enumerated set of decision making situations. An example:

| Dynamic Tactical Response Table | | | | |
|---|---|---|---|---|
| **{COMMANDER TYPE, TRIGGER TYPE}** | | | | |
| Operational Applicability: | {Commander Subtype(s) and/or Instances(s)}<br>{Command & Control Mode(s)}<br>{Mission Type(s)}<br>{Attack Readiness Condition(s)}<br>{Scenario Time Interval(s)}<br>{Scenario Phase(s)} | | | |
| **Tactical Trigger Conditions** | Dynamic Responses | | | |
| | **Response Type 1** | **Response Type 2** | • | **Response Type n** |
| {Condition Set 1} | { Priority; Criteria; Action(s)} | { Priority; Criteria; Action(s)} | • | { Priority; Criteria; Action(s)} |
| {Condition Set 2} | { Priority; Criteria; Action(s)} | { Priority; Criteria; Action(s)} | • | { Priority; Criteria; Action(s)} |
| • | • | • | • | • |
| {Condition Set n} | { Priority; Criteria; Action(s)} | { Priority; Criteria; Action(s)} | • | { Priority; Criteria; Action(s)} |

**Example Trigger Conditions:**
- Detect SA-10 lock-on
- Detect > 3 Mirage 2000's

**Example Criteria**:
- Within region
- Within range

**Example Responses**:
- Message routing plan
- Motion modification plan
- Engagement package

# C2 TERMS OF REFERENCE RESPONSES

**(4) Simulating Unit Behavior:** What basic approach did you take to simulating unit behavior? What influenced this approach?

- User specified **plans** and dynamic response **decision tables** define the scripts and rules by which the decision process is simulated.

- Each plan has a well-defined context; e.g. strike warfare. These often closely mirror operational order formats, e.g. air tasking orders (ATOs).

- Each decision table also applies to a specific doctrinal context; e.g. anti-air warfare commander (AAWC) on CG-52 receives a specific I&W report.

- Each decision table has a well-defined context; e.g. AAWC conducting BG air defense. These often closely mirror published tactical procedures; e.g. fighter squadron tactical procedure (TACPRO) memoranda.

# HBR TERMS OF REFERENCE QUESTIONS

DESIGN ASPECTS OF SIMULATIONS REPRESENTING HUMAN BEHAVIOR

- **Human-in-the-Loop (HITL).** Does HITL play a role in your model? At what echelon (or echelons) does the simulation reflect the influence of HITL? To what extent is the simulation play reflective of HITL?
- **Aggregation of Units.** Discuss your approach towards the aggregation/disaggregation of units at various levels.
- **Changes in Organization.** How does your model allow structural and functional changes in the command organization?
- **Representation of OPFOR.** Does your model represent OPFOR and third-party players at the same level of detail as it represents friendly forces?

# HBR TERMS OF REFERENCE RESPONSES

**(1). Human-in-the-Loop:** Does HITL play in your model? At what echelon (or echelons) does the simulation reflect the influence of HITL? To what extent is the simulation play reflective of HITL?

- NSS is currently constructive only; e.g. simulated commanders operating simulated systems/forces.
- In FY-96 NSS will be extended to permit live interactions at the group or WMA commander levels.
- Targeted user group is OPNAV N81 and J-8/WAD for analyst-in-the-loop operations.

**(2). Aggregation of Units:** Discuss your approach towards the aggregation of units at various levels.

# HBR TERMS OF REFERENCE RESPONSES

**(3). Changes in Organization:** How does your model allow structural and functional changes in the command organization?

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**(4). Representation of Opposition Forces:** Does your model represent OPFOR and third-party players at the same level of detail as it represents friendly forces?

# HBR TERMS OF REFERENCE QUESTIONS

OTHER ISSUES

- **Data.** Did ready access to data influence your choice of methodology? What data are needed to better model commander behavior that you have not yet collected?
- **Required Research Areas.** Are there areas that you feel theoretical research needs to be conducted?
- **New Applications.** Are there areas where you feel important applications can be developed given time and funding?

# C2 TERMS OF REFERENCE RESPONSES

**(1) Data Issues:** Did ready access to data influence your choice of methodology? What data are needed to better model commander behavior that you have not yet collected?

- Data comes from published tactical doctrine. Doctrine lends itself to DT approach.
- Responses to unanticipated situations is a continuing problems for DT approach.

**(2) Required Research Areas:** Are there areas where you feel theoretical research should be conducted?

- Assess the tradeoffs between comprehensibility/simplicity and generality. Are decision tables "good enough"? Are more exotic AI-based knowledge representation approaches needed and feasible?
- Campaign-level dynamic decision making (e.g. responsive changes to high-level objectives and plans). Can this be simulated constructively? Is MITL required?
- INTEL processes. To what extent can highly multi-data-source, highly cognitive INTEL assessment processes be simulated?

**(3) New Applications:** Are there areas where you feel that important applications can be developed given time and funding?

- OPLAN generation/reading tools for all services. To the extent possible, simulations should read in and output operational plans (e.g. ATOs, ITOs, etc.) in standard military formats. General tools supporting this process are needed.

# SUMMARY

- NSS is a constructive (virtual) simulation which explicitly models complex command structures, commander dynamic decisionmaking, operational plans and tactics, tactical picture generation (perception), surveillance, and communications.

- Modeling of human tactical decisionmaking in NSS is largely scripted at the National/ Theater levels but is fully **dynamic** and reactive at the Force/Unit levels.

- Commander behavior is specified (by the analyst or fleet user) via formatted **plans** and dynamic response **decision tables**.

- Commander behavior is predicated on the **perceived tactical picture**, fused from inputs from sensors reporting over established communications links.